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Art. XXV.—*The Tropics and Pigment: The Physical Properties of Pigment, and its Physiological Importance in the Protection of Living Organisms, Especially Man.*

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[Read 14th December, 1911.].

In 1906 I set out on a world's tour, which extended over a period of three years, and embraced in its itinerancy the eastern part of Australia as far as Port Darwin, Java, Malay States, Eastern China, and Mongolia, Japan, Canada and the United States, the Countries of Europe, Asia Minor, Egypt, Nubia and India.

I made the object of my travels the solution of the Race Question, which resolved itself into three divisions of enquiry, viz: —

1. The physiological importance of colour in man.
2. The relation of man to his environment.
3. The purpose of Race.

It is with the first of these questions that we are now concerned, which enquiry has been extended to include all living organisms.

Before proceeding to discuss the subject, it is advisable to give some account of the current literature upon it. The International Scientific Catalogues up to 1910 record many contributions upon pigmentation, but such as I can obtain in the Melbourne libraries deal chiefly with the anomalies of pigmentation or the questions of climatology, and with these may be included Keane, Scholes, and the Report of the last Race Congress held in London in 1911. The only work that need seriously demand our attention is Woodruff on "Tropical Light."

On page 85 he truthfully states: —

"Man is invariably covered with pigment which acts as an armour to exclude the more harmful short rays, and, moreover,

the amount of pigment is in direct proportion to the intensity of the light of the country to which his ancestors had proved their adjustment by centuries or millenniums of survival in health and vigour."

But he misses the mark when he writes on page 68:—

"Of course the surest colour is black, for it destroys all the short rays, but as it transforms them into long rays the animal would be put in jeopardy from heat. . . . Hence black animals are almost always nocturnal."

Among these nocturnal animals Woodruff includes the black man:—

"The negro is really a nocturnal animal, like other black animals of the Tropics."

And further, when he discusses "Hirsuteness," his curious statements are almost grotesque, as shown in the following extract:—

"We rarely appreciate how transparent the scalp and skull really are. A candle in an empty skull shines through quite plainly. Hence a hairless head would permit strong light to penetrate to the delicate nerve cells which are here directly on the surface, and it would be fatal. The greater amount of light there is in a country, the thicker and blacker is the head hair. It is perfectly evident why the ancient European's wavy hair should become more and more kinky as man slowly migrated south, for it is thus a better protection from light. There is then no enigma in the apparently useless masses of kinky hair of the negro. The hair is not needed as protection from the heat or cold, for it is profuse in all countries, but it is a protection from the light."

Leaving Dr. Woodruff for the present, we are now free to seek for further evidence of the present state of knowledge on this question from the actions and utterances of the Melbourne academic authorities.

Professors Spencer and Gilruth, at the request of the Commonwealth Government, visited this year the Northern Territory, to survey the land in favour of a white settlement. They have now returned, and their report is favourable. Professor Osborne, in the course of the 1911 University Stewart Lectures on "Climatology" (as yet unpublished) prefaced his remarks by stating that

he was on the eve of an ethnological tour, during which he hoped to come to some solution of these difficulties. He went on to declare himself in favour of race purity, and said that by the aid of red roads and a system of cool storage, with due regard to wet bulb readings and hygiene, the white man might ultimately hope to maintain a permanent hold in the tropics. Professor Allen, in a personal interview with the writer, also declared for race purity, and hoped that by the aid of science and the inculcation of habits conformable to the situation, the white man might maintain a permanent occupancy of the tropics. He instanced the present condition of the Panama under American administration. He, however, did not state that the great mass of unskilled labourers were coloured men gathered from anywhere and everywhere, while the skilled white labour had all the protection that American ingenuity could contrive for them.

Then again we have Dr. Barrett's letter in the "Argus" of October 14th, 1911, appealing for a Chair of Anthropology, in which he writes:—

"We might from such a Chair learn accurately how it is that the coloured man so far holds the Tropics. We might discover the elements of structure and functions which he may possess and we do not, that has enabled him so far to hold his tropical dominion."

And it is to this enquiry that the following statement is an answer, viz.:—

That the pigment of a black man protects him against the violence of radiant heat, as well as against light and actinic rays, by converting these energies into actual heat, which in turn is dissipated by the evaporation of moisture, this moisture being the result of the reflex stimulation of the sweat glands set up by the heated pigment, which is buried in cells in close contact with the nerve terminals.

This statement will explain the difference between heatstroke and sunstroke; why a Chinaman carries a fan, and an English tourist an umbrella. These questions are dealt with in another portion of the paper. But what is more important to Australians, it declares that tropics must ever remain the home of the coloured man.

Some evidence may now be adduced in support of the above statements. The truth will be obvious to those who are familiar with the laws which regulate radiant energies and the wet bulb thermometer as recorded in Balfour Stewart or Deschanel's Elementary Physics, combined with a knowledge of the histology of the skin as in Schäfer, and of the functioning of the sweat glands, to be found in any up-to-date work on physiology.

Physical science clearly demonstrates the fact that the pigment embedded in the rete malpighian layer of the skin of man and animals, will, in proportion to the density of the deposit, arrest the radiant energies of the sun, transforming and absorbing them as heat. This, in a measure, is advanced by Woodruff, but his difficulty was the disposal of the heat, for he only regarded pigment as a protection against the evils of light, but which would otherwise render the coloured man more vulnerable to heat. To get over his dilemma he describes the black man as a nocturnal animal. He failed to see that pigment is in a position to control the functioning of the sweat glands, and that instead of the heat being absorbed and dispersed by radiation, it could be dissipated in the evaporation of sweat. Woodruff, on page 86, states:—

"Undoubtedly the negro, when in the shade, is able to radiate heat better than whites, and this enables him to keep cool in the Tropics, but put him at a disadvantage in the North, where a white man can keep warmer with less clothing and less fire in the house. But it is a secondary cause enhancing the first, because, when it comes to a question of light and cold, Nature makes no mistake, but selects a colour able to exclude the light."

In the disposal of his body heat the pigment of a black man may give him some advantage, as an absorber and radiator, over the white man, but a black man is something more than a pigmented lump of clay, and even in the matter of loss of heat by evaporation of sweat, something more than a porous water bottle. He certainly responds to the laws that regulate the heating and cooling of inanimate things, but it is all important that we should recognise the physiological significance of the histological elements that lie buried in his skin, constructed to meet the exigencies of light and heat.

The pigmented epithelial cells which form the rete malpighii lie in contact with the corium. Through the meshes of the rete, filaments of the nerves pierce and interlace over its surface, so that the particles of pigment are in the closest contact with the surrounding nerve structure. Thus the variations of internal and external temperature which affect the pigment granules, would be directly imparted to the nerve terminals, and thence a communication to the central nervous system, with a corresponding reaction on the superficial blood-vessels. If the pigment is heated, a dilatation of the blood-vessels follows, with a flushing of the sweat glands. If the pigment is chilled, then a contraction of the blood-vessels takes place, which tends to prevent the loss of heat. It is natural, then, to conclude that pigment renders a man more sensitive to the cold, but this offers no impediment to a coloured man's progress, or even a black man's, for we find them both wandering from the equator to the poles, The Laplander and Eskimo are coloured men, and it was reported in the daily press that an American negro accompanied Captain Peary in his final rush for the Pole. Captain Peary's reason for this was that he considered that the black man, on account of his pigment, was better able to meet the emergencies that might arise from exposure.

Experimental evidence of the physical properties of pigment can be easily demonstrated by a piece of smoked window glass. We are all familiar with the protection that the deposit of smoke affords to the eyesight, but to appreciate the fact that it will also protect us from the sun's heat, alternately interpose between the exposed skin and the sun's rays a piece of glass smoked, and another not smoked. The effect can be heightened by concentrating the sun's rays with a biconvex glass condenser. The carbon will transform and absorb the rays in proportion to the density of the deposit. The heat will be radiated, but it may be dissipated by the evaporation of fluid if some spirituous liquid is poured over the glass. A similar result was obtained by the use of melanin pigment. The pigment for this experiment was procured by Dr. Stapley, of the Melbourne Veterinary School.

To show that pigment interferes with the passage of the sun's rays through animal tissues, the radiance of translumination of

an electric lamp placed in the mouth will readily demonstrate this fact by comparing the fair with the dark skins, or by artificially darkening the skin with melanin pigment, burnt cork, sol. nitrate of silver, etc., or, perhaps what may be more simple, compare the transparency of variously pigmented skins by holding their hands before a beam of sunlight.

Our next object in the course of experimental evidence is to show what proof there is of heated pigment re-acting on the circulation, and increasing the activity of the sweat glands. From personal experience I know that heat reddens the skin and promotes sweating, and from personal observation I also know that the black man, of all men, is a profuse sweater.

We can, so far, sum up this discussion by confidently affirming:—

(1) That pigment, in proportion to the density of the deposit, renders the skin opaque to the sun's rays.

(2) That pigment transforms these energies into heat.

(3) That the temperature of the pigment reacts on the blood-vessels of the skin.

Thus, heated pigment induces sweating, whereby heat is dissipated.

Heatstroke.

From what has already been stated, it can be concluded that in the shade, all other things being equal, the power to resist high temperatures, dry or moist, is in favour of the pigmented skins, but the individual will succumb when it has reached the limits of his physiological activity. In exposure to the sun, there is an obvious advantage that pigmentation bestows on diurnal animals. It permits the loss of the body hair so that it shall not be an impediment to dispersion of heat by the evaporation of sweat, as with the buffaloes of Southern Asia. To man it gives the same security, his pigmented skin enables him to do without clothes, and nature, as is well known, reduces the hair of the scalp in many negroes to small, woolly tufts whereby danger from heat is reduced to its minimum.

It is a curious deduction of Dr. Woodruff to conclude that a negro's kinky hair is designed by nature to protect him from light, especially in face of the evidence he might have obtained

from Southern Asia, where millions shave their heads as a political or religious observance, and freely expose themselves to a tropical sun without any fear of disaster. Such could not be tolerated did it in any way imperil their comfort, let alone their life. The coloured man wears a turban because he wears his hair.

Sunstroke.

Sunstroke menaces the white man, and he is apparently the only animal that can suffer from it. When you enter the tropics your first concern is to secure a helmet hat, for your acquaintances will have warned you of the dangers you run if you dare to expose your head and nape of neck to the sun. A few minutes is sufficient in some instances for the sun to exact its penalty. Thrust your hand into ice cold water for three minutes, and it will chill your whole body by means of the circulation. Expose your head or nape of the neck for three minutes to a tropical sun, and enough of its energies are poured into the brain to seriously affect its function. They pass into the cutaneous tissues, and are carried thence by the circulation to the nervous system, or, from analogy with the shadow of the Roentgen rays, direct rays from the sun may be transmitted through the scalp and skull to the brain direct.

I do not purpose discussing the pathology or any other of the factors that enter into the aetiology of sunstroke. It suffices to state, as already demonstrated, that a pigmented skin arrests the sun's rays, so that a black man in the normal circumstances of his life cannot suffer from sunstroke; but in the unprotected white man, these rays are free to enter with inevitable disaster.

The Chinaman and His Fan.

The Chinese present many gradations of pigmented skins, from a light lemon colour to a dark tan.

Canton city produces the finest samples of the lemon yellow, while the coolie and the peasant of the southern provinces possess the darkest tan. One of the most familiar sights to be seen in the streets of the European settlement is a lightly pig-

mented Chinaman with his head shorn and bare except his pig-tail, clothed in his native garb, sauntering along flapping his fan, evidently for the sake of comfort rather than from any fear of his safety. He is sensitive to heat and not to light. Putting this into scientific phraseology, his skin, in relation to the demands of his environment, is diathermanic and non-actinic.

Diathermancy is not a term often used in experimental physiology, vegetable or animal, for I have only met the word once, and then in Ewart's translation of Pfeffer, where it is stated that the essential oil exuding from a plant interferes with the diathermancy of the atmosphere. Deschanel gives experimental evidence on this subject. Diathermancy is the quality of transparent bodies which permits the passage of radiant heat. This quality varies with the nature of the substance, also with its colour and its degree of opacity. This property of transparent bodies can easily be demonstrated in the sunlight with a few pieces of window glass, plain and coloured, a convex glass condenser, and some inflammable material, such as paper or matches.

Interpose these glasses between the condenser and the match, and note the time it takes to ignite them. Still better, use aniline dye, first with a transparent dye and then adding a mordant which causes a deposit on the glass, and makes it more or less opaque. It then resembles the condition of the pigment in the skin. This experiment distinctly shows that colour interferes with the passage of radiant heat; but with a deposit thrown down by the mordant, the heat can be entirely excluded.

The skin, which is more or less transparent in a white man, as shown in the act of blushing, permits the transmission of radiant heat as well as light; but the black man is born to blush unseen, for his pigment makes his skin opaque and prevents the passage of these rays.

The comparative value of pigment in obstructing the passage of the sun's rays has been already referred to in this paper by the experiment of introducing an electric light into the mouth and noting the illumination. In the white man the transparency is most marked, less in the yellow and least in the black man. So it is safe to assert of the Chinaman and his fan that his yellow skin will control actinic radiations, while it permits the passage of yellow light, and with it more or less radiant heat.

The English Tourist and His Umbrella.

Any of us who have lain suffocating on the deck of a steamer as it passed through the Suez Canal and have seen the native Arab children racing along the banks begging for "backsheesh" must be compelled to admit that the Arab has acquired some immunity which the white man does not possess. The traveller on the steamer enjoys the advantage of hygienic surroundings, and is protected by all that science can afford him, except a refrigerator, yet the Arab runs across the burning sand, into which he frequently tumbles, with a happy unconsciousness of any discomfort, and sublimely ignorant of the perils of light, heat, and a humid atmosphere. This incident accurately illustrates the relative position of the white and black races in the tropics. Visitors only invade them during the winter months, and then they are armed with every comfort. At the approach of summer the white races fly to the hills or some other clime for safety. The only explanation to the situation is that the white man is both actinic and diathermanic, and feels the necessity of protection, even to the use of an umbrella.

The use of the words actinic and diathermanic mean that the white man's tissues permit the penetration of light and heat rays. How far these rays penetrate it is difficult to determine. Translumination, as already shown, gives evidence of transparency. The light rays are visible, and the presence of actinic energy is revealed by photography. To determine the passage of radiant heat the following experiment may be performed:— Place in the mouth, with the electric lamp, a thermometer, and with the face of the individual near a thermopile, all other sources of heat being eliminated, discover, if possible, the presence of radiant heat. But of the actual resistance of the tissues to sunlight the following simple experiments will give some evidence. Free blood is opaque. Smear a little between two glass slides, then hold it to the sunlight, and it will be seen that the blood obstructs vision, though transmitting a diffuse red glare; now interpose the test slide between a condenser, focussing sunlight on the head of a match. It will not ignite, the blood having absorbed the heat rays. While recognising

the abnormal condition of the blood in this experiment, we can with some assurance conclude that blood in the tissues will have power to reduce actinic and heat energy to actual heat, and absorb all light rays but red. Thus the reddening of the skin on exposure to heat is really nature coming to the rescue. It not only flushes the sweat glands, but its flowing streams gather up the heat and carry it to other parts of the body to be dissipated.

The Tropics must ever remain the home of the Coloured Man.

The white man, in his natural home, lives under the happiest circumstances for the condition of physical adornment. He inherits all the charm of variety, while his less favoured coloured brethren are burdened with the brand of monotony, and suffer by comparison. But let the pale face wander, then, the fairer his skin, the more susceptible is it to the ills that such flesh is heir to. The white man is truly the product of green fields. Born in areas where the hours of sunshine are duly recorded, he lives a strenuous life; but when he leaves his native land his capacity for labour varies inversely as he nears the equator or the poles.

On reflection the above statements should now be obvious, but it may be of advantage to adduce some further evidence in their support. The Panama is a noble tribute to medical skill; there the death rate of the white population has been reduced to half that which it is in New York; yet the 6000 whites in the Panama are the black man's burden, as they are everywhere else in the tropics. Cornish's "History of the Panama" and Weir's "Conquest of the Isthmus," both published in 1909, give interesting and instructive accounts of the situation. The great army of the toilers in the Panama are coloured men, gathered from anywhere, amongst whom these writers include Italians and Spaniards.

Since prehistoric times the northern white races have been over-running the south of Europe, but Southern Europe still remains coloured, the great mass of its inhabitants being as dark as many of the Asiatics of Southern Asia. Apart from the question

of disease, my own experience of the tropics has shown me that the white man in the black man's country degenerates mentally, physically, and morally, and that his children are attenuated specimens of his race. Thus I am compelled to affirm that labourers will ever need the protection of colour in direct relation to their environment.

The Complex Nature of Animal Pigments.

As our subject was extended to include all living organisms, some reference must be made to the complex nature of their pigmentation. To understand the reason of the diversity of colour that appears in animals, it is necessary to look into the conditions that give rise to the need of colour, and they may be best presented by the following homely illustration:—

A man may put on any old coat to protect himself from the sun's rays, but a soldier needs the security of colour, and wears khaki. To distinguish the officer, he is adorned with gold braid and buttons, a most powerful weapon in the struggle for sexual selection. So it is with animals. Any old coat seems to serve our domestic companions, whilst animals that live in peril of their lives are warily clothed; and others, who are free from that anxiety, are adorned for the struggle of sexual selection.

Behind these *post hoc* performances there is some subtle agent at work, the biological factor, life. A man's circumstances may demand a coat, but these circumstances do not make the coat, and so it is with Nature's "visible garments." But the coat is constructed out of matter and force, and so one must conclude that the factors that are concerned in the production of pigment are—life, matter and force. In declaring an adherence to this three-fold division, one is privileged in that much of the dogma that has been founded on hypothetical science is in a state of flux. But life, matter and force exist, and in distinguishing the vital from the physical I will here simply assert my claim as an article of faith.

The influence of breeding on colour determines the importance of the biological factor, which shows its highest effort in sexual selection. It is not required to give evidence that matter, as a change of food, and force, as a change of environment, will also

effect a change in the colouring of various animals, but what is remarkable is the subtle adaptations of Nature to the refined variations of environment. This is seen in the tapeta that exist in quadrupedal mammals, whose eyes are in a position to receive a great amount of reflected and transmitted rays. The tapeta, which are, no doubt, needed for the protection and function of vision, are so varied in their colour schemes that they almost rival in beauty anything that Nature has attempted for the purpose of sexual selection. This fact will account for the varied colour schemes that appear in the coats of animals living continuously in subdued and modified sunlight, and which are so essential for their protection.

Chlorophyll and Plant Life.

The object of including vegetable organisms in this discussion is to show that there is a common purpose underlying the functions of pigment in all living organisms. Vegetable pigment is much more complex than that of the surface pigment of animals, yet it is also designed to protect the tissues from the violence of the sun's energy.

The sun's energies are necessary for physiological processes that take place in vegetable organisms, but while they are the constant stimulant of these vital phenomena, over-stimulation can suppress the activity of these processes and bring about the ultimate destruction of the living media through which they are being transmitted. Therefore, plant life is compelled to construct a wall of resistance by which these energies can be regulated. It is evident that this purpose is mainly accomplished by the deposition of chlorophyll. Chlorophyll, because of its colour, has the power of controlling light rays, and also because of its colour and opacity, of obstructing the passage of heat rays, and it therefore regulates the diathermancy of the tissue involved. Its capacity in these directions will vary with the density of the deposit of pigment.

The truth of the above statements can be demonstrated, as was done in the case of animal pigments, with aniline dyes, chlorophyll pigment, or the translumination of vegetable tissues.

The synthetic properties of chlorophyll depend chiefly upon its chemical constituents, and no doubt the physical properties of the pigment may enter largely into effecting the changes that take place in the chloroplasts. But we are not concerned with either the chemical or vital processes themselves, we are only dealing with the physical properties of chlorophyll as a pigment, and are more particularly concerned in showing that it has the power of controlling the activities of light and heat rays; and this will be readily conceded if we attempt to explain the ordinary phenomena that occur in the course of plant life.

Young plant life is vigorous, and radiant energies are freely demanded for the purposes of rapid growth. Here it will be observed that the deposition of pigment is least. As the season and growth advance the deposit increases, which in turn must lessen the chemical activity of light, and at the same time reduce the diathermancy of the tissues. This means the conversion of more of these radiant energies into actual heat, till at the end of the season or of growth the chlorophyll has become so dense that it will, for the greater part, if not wholly, transform these energies into heat. With annual plants, as in grain crops, the pigment changes its colour to a yellow pigment, xanthophyll. This pigment has the power of further reducing actinic energy to heat, and at the same time, in some measure restoring the transparency of the tissue and allowing the transmission of radiant heat, which in due course completes the ripening of the grain. With the deposition of pigment, the growth of perennial foliage is completely arrested, as with the ivy, but by this means these leaves are able to secure the necessary heat that sustains them through the winter months, while in the summer desiccation is avoided by the transpiration of fluids.

Here again experimental evidence can be given in support by the translumination of the various coloured vegetable membranes.

It is not necessary to give evidence that Nature protects plant life according to the needs determined by its environment, nor is it required to prove the fact that British trees, like British people, find the struggle of life increases adversely as they near the equator or the poles.

We can, again, sum up the discussion by affirming of vegetable pigments: —

(1) That the pigment, in proportion to the density of its deposit, renders the tissues opaque to the sun's rays.

(2) That pigment transforms these energies into heat.

(3) That the temperature of the pigment reacts on the circulation of the sap.

Thus heated pigment induces the transpiration of fluids whereby heat is dissipated.